REMARKS

Claim 31 has been canceled, thereby obviating the objection to such claim.

Claims 14-15, 20-22, 25-26 and 36-40 are rejected as being unpatentable over Lee et al (U.S. 6,514,113) in view of Dai et al. The Examiner has taken the position that Lee et al disclose production of carbon nanotubes using a substrate formed by coating a metal film of aluminum over a substrate of silicon, alumina, quartz or glass, and then forming a catalytic metal film, such as that containing cobalt, nickel or iron, on the substrate to grow aligned carbon nanotubes (page 2, penultimate paragraph of the Office Action). The Examiner relies on Dai et al to remedy the Lee et al failure to disclose calcining the substrate before growing the carbon nanotubes.

Applicants have discovered that by using an aluminum-deposited porous silica alumina substrate in the process of the present invention, an aligned carbon nanotube ("CNT") film is obtained having a high density and with CNTs whose external diameter is as low as 5-8 nm. Neither Lee et al nor Dai et al disclose use of a porous silica-alumina substrate for producing CNTs.

The porosity of the silica-alumina support allows an aqueous solution or suspension of a metallic catalytic compound to be uniformly applied over the surface of the substrate. The deposited aluminum can contribute to the formation of catalysts for production of carbon nanotubes (CNTs) whose external diameter is as low as 5-8 nm. According to the subject invention, by loading an aqueous solution or suspension of a metallic catalytic compound on the layer, then calcining it, the desired catalytic particles can be obtained.

The unobvious advantages derived from an aluminum-deposited porous silica-alumina sheet are demonstrated in the Someya et al Declaration submitted herewith and described therein in detail. Briefly, an aligned CNT film was obtained by using an aluminum-deposited porous silica-alumina sheet, but an aligned CNT film could not be

obtained with a non-porous silicon wafer substrate, nor an aluminum-coated non-porous silicon wafer. When using a silicon wafer as in Comparative Example A of the Someya et al Declaration, CNTs could not grow. Instead, carbon particles were obtained as shown in SEM image B on page 4 of the Someya et al Declaration. When an aluminum film was deposited on the non-porous silicon wafer in Comparative Example B, an aligned CNT film was not formed, but CNTs grew perpendicular or normal to the surface on a minor portion, while on the major portion of the surface, the CNTs grew parallel to the surface (SEM images C-E). Thus, an aligned CNT film was not produced.

The aligned CNT film of the present invention has advantages for productivity and further processing. The subject invention provides an aligned CNT film having a high density such as 400 CNTs per 1 μm^2, as indicated in paragraph 5 of the Someya et al Declaration, allowing efficient production of CNTs. Furthermore, such a high-density film is suitable for applications including an electron emitter, where a bundle of CNTs such as a CNT array is required to achieve a sufficient current. Moreover, the aligned CNT film can be easily removed from the substrate, and be easily provided for further processing.

The shape of each CNT obtained according to the subject invention is also suitable to industrial applications including a field emission microcathode of a display. The external diameter of CNT obtained was as low as 5-8 nm, and the length could be equal to or more than 10 μm. Such a small diameter is preferable for field emission, since an applied voltage is focused in a small area and causes enhanced electron emission.

When CNTs are utilized as an ensemble or an assembly, the small external diameter, as well as the large aspect ratio, advantageously contribute to improved stiffness, electrical conductivity, and heat conductivity of the ensemble.

By the present amendment, independent claim 14 has been amended to specify that the substrate is porous silica-alumina. Support for this amendment is found on page 5, lines

4-14 of the present application. Additionally, claim 14 has been amended to recite that the catalyst is loaded by means of an aqueous solution or suspension and that the metallic catalytic compound is converted to a catalytic metal oxide. Support for such recitations is found on page 8, lines 2-3 and page 9, lines 20-29. Likewise, support for the recitation concerning depositing of aluminum is deposited is found on page 6, lines 10-14, as well as page 9, line 15 and page 11, lines 10-11.

Claim 14 and the claims dependent therefrom clearly distinguish Lee et al. Lee et al. disclose that the substrate may be formed of silicon, alumina, quartz or glass, and preferably of glass. As demonstrated in the attached Someya et al Declaration, Example A (pages 2-3), which corresponds to Example 3 of the Someya et al application, shows the use of a porous silica-alumina sheet with deposited aluminum that is dipped in a catalyst suspension, calcined and then used as a substrate for deposition of carbon for producing an aligned CNT film having a thickness of about 100 μm. As indicated in paragraph 5 of the Someya et al Declaration, use of the process of the present invention produces CNTs that grow vertically to form the aligned film as shown in Fig. 1 of the Someya et al application.

In contrast, the Example A procedure was repeated in Comparative Example A, but a silicon wafer replaced the porous silica-alumina sheet and the aluminum deposition was omitted (page 3, second full paragraph). The resulting surface of the substrate revealed clusters of carbon particles sporadically forming on the surface (SEM images A and B on page 4), but no aligned CNTs were formed. In Comparative Example B, the procedure of Example A was repeated using a silicon wafer, as in Comparative Example A, however, a aluminum film was deposited prior to application of the catalyst and calcined. As discussed on page 5 of the Declaration and shown in SEM images C, D and E on page 6, an aligned CNT film was not produced. Rather, aggregations of bundles of aligned CNT were formed in

minor areas of the surface, while CNTs on the major area of the surface were parallel to the surface rather than normal or perpendicular thereto (SEM image E).

Accordingly, the Comparative Examples of the Someya et al Declaration visually demonstrate that use of an aluminum-deposited porous silica-alumina substrate produces an aligned CNT film, while a non-porous substrate, even having an aluminum film does not provide an aligned CNT film, thus demonstrating the unobviousness of Applicants' claimed invention using a porous silica-alumina substrate.

The substrate of glass in Lee et al is suitable for a sealing process of completing a white light source (column 4, lines 4-7). For this application, the interior of the system should be kept in high vacuum. Therefore, a porous material, which can cause gas release, is not preferable; instead, a non-porous glass substrate is preferable. In contrast, the unexpected advantages of the subject invention are achieved by using a porous silica-alumina. Therefore, the description of the Lee et al. patent teaches away the subject invention.

Furthermore, the process of the subject invention provides an aligned CNT film in a simple manner as compared to the process of the Lee et al. patent, which requires grain boundary etching. As pointed out on page 3, lines 6-14 of the present specification, anodization or etching results in nanotubes greater than 20 nm. On the other hand, Lee et al disclose that grain boundary etching takes place to separate the catalytic metal film into fine isolated catalytic metal particles (column 5, lines 42-54). Lee et al then state (column 5, lines 55 et seq.)

> "Thereafter, a carbon source is provided on the catalytic metal film 300 to grow the carbon nanotubes 400 from individual catalyst metal particles."

In the Lee et al process, an aluminum film is utilized as a cathode (column 4, line 49). In contrast, the aluminum film of the present invention serves as a support on which catalytic particles can be grown by the loading and calcining steps. This role of an aluminum film of

the subject invention is not disclosed or suggested by Lee et al. Furthermore, in the Lee et al process, catalytic particles are made of metal, since they are produced by grain boundary etching of a metallic layer. In contrast, catalytic particles of the subject invention are made of metal oxide, since they are formed via the loading and calcining steps.

In order to further distinguish Lee et al , claim 14 has been amended to recite that the process "consists essentially of" the recited steps. The use of the language "consists essentially of" has been judicially interpreted to exclude steps which would materially affect the basic and novel characteristics of Applicant's claimed process. *In re Herz*, 537 F.2d 549, 551-2, 190 USPQ 461,463 (CCPA 1976). Thus, such language excludes the grain boundary etching required by Lee et al, since it would materially affect the basic nature of Applicant's process.

Thus, Applicants' process merely requires that a aqueous solution or suspension of a metallic catalytic compound be simply loaded on an Al-deposited porous silica-alumina sheet, and is calcined to form a substrate.

In summary, the Lee et al patent is deficient since; 1) Lee et al do not disclose use of a porous silica alumina support; 2) the Lee et al process does not produce an aligned CNT film as shown by the Someya et al Declaration; 3) the aluminum film of Lee et al functions as a cathode while in Applicants' process it functions as a catalyst support for loading and calcining; 4) the Lee et al catalyst particles are metal and not metal oxide, as in Applicants' process; and 5) Lee et al require grain boundary etching, which is excluded by Applicants' claimed process.

Dai et al do not remedy the many deficiencies of Lee et al. For example, Dai et al do not disclose use of a porous silica-alumina substrate nor use of deposited aluminum in the preparation of their probe. For these reasons alone, the combination of Lee et al with Dai et al can not render the claimed invention obvious.

The Dai et al patent relates to a probe of AFM, and not an aligned CNT film. In the Dai et al patent, a small number of CNTs, for example, one to nine CNTs, grow from each pyramidal silicon tip, and the length of the CNT is in the range of 1-10 μm, as shown in Figs. 1B, 1C and 4, as well as in the description in column 2, lines 53-61. The form of the CNT ensemble and the shape of each CNT of the Dai et al patent is suitable for a probe of AFM. A substrate containing silicon pyramidal tips is preferably used in view of preparation of an AFM probe, as described in column 4, lines 58-63.

However, the present invention relates to an aligned CNT film, the form of which is considerably different from an AFM probe. Thus, the object of the present invention is far different from that of the Dai et al patent. In view of the differences between the Lee et al and Dai et al patents, one skilled in the art would not be motivated to combine such diverse teachings.

Moreover, as indicated above, since Dai et al do not disclose use of a porous silica-alumina substrate nor use of deposited aluminum, the combination of Lee et al with Dai et al can not render the claimed invention obvious. Thus, where a reference does not disclose a feature of a claim relied on to distinguish the prior art, it cannot suggest modifying the prior art to contain that feature, see *In re Civitello*, 144 USPQ 10 (1964) wherein the CCPA stated:

> Since Haslacher fails to <u>disclose</u> the feature of the claim relied on, we do not agree with the Patent Office that it would <u>suggest</u> modifying the Craig bag to contain that feature. The Patent Office finds the suggestion, only after making a modification which is not suggested, as we see it, by anything other than appellant's own disclosure. This is hindsight reconstruction. It does not establish obviousness. (Emphasis the Court's).

See also *In re Glass*, 176 USPQ 489 (1973) wherein the CCPA stated that it is error to ignore specific limitations distinguishing over the references.

Although the foregoing comments were mainly directed to claim 14, they are even more applicable to claims 15, 20-22, 25-26 and 36-40, since such claims are ultimately

dependent from claim 14, but include additional preferred features. Claims 29 and 31 have been canceled.

Accordingly, the rejection of claims 14-15, 20-22, 25-26 and 36-40 over Lee et al in view of Dai et al should be withdrawn.

Claim 30 is rejected as unpatentable over Lee et al in view of Dai et al in further view of Ohki et al. Claim 30 has been cancelled, thereby obviating the rejection of this claim. Moreover, the combination of Lee et al with Dai et al fails to teach or suggest the claimed process for the reasons given above. This defective reference combination would not be remedied by Ohki et al., who disclose use of alumina or silica alumina to avoid heat damage, and do not disclose use of a porous silica-alumina sheet in the claimed process.

Claims 16-19 and 32-35 are rejected over Lee et al in view of Dai et al, and further in view of Hafner and U.S. Patent No. 4,244,938 to Alkaitis. Claims 16-19 are ultimately dependent from claim 14. Thus, the deficiencies of the combination of Lee et al with Dai et al are herein applicable as well. Moreover, like Lee et al and Dai et al, neither Hafner nor Alkaitis disclose use of a porous silica-alumina sheet as a ceramic substrate for the claimed process. Accordingly, since none of the combined patents disclose a porous silica-alumina substrate, the rejection of such claims should be withdrawn.

Similarly, since claim 32 has been amended to recite use of a porous silica-alumina sheet and recite that the process "consists essentially of" the recited steps, the rejection of claim 32 and claims 33-35, which depend from claim 32, over Lee et al in view of Dai et al, and further view of Hafner and Alkaitis, should be withdrawn as well for the reasons given above.

For the foregoing reasons, the claims are now in condition for allowance and should be passed to issue. Such action is earnestly solicited.

Respectfully submitted,

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Dated: November 5, 2004